SINGLE-PHASE CONVERTER MODULE

The present invention relates to a converter module having a component/contact stack configuration according to the definition of the species in Claim 1, and a method for manufacturing such a converter module according to the definition of the species in Claim 8.

Converters are used for converting electric power by using converter valves such as, for example, diodes, thyristors, transistors, etc. They are configured as rectifiers, inverters, or converters, depending on the application. In the automotive field, converters are used in particular as rectifiers which convert an A.C. voltage, supplied by a vehicle generator, into a D.C. voltage for supplying a vehicle electrical system.

A rectifier known from the related art is illustrated in Figure 1 as an example. Figure 1 shows a rectifier bridge circuit for an alternator, which converts the alternator's three phases U, V, W into a D.C. voltage. For each phase U, V, W, the rectifier includes a pair of Zener diodes 8a, 8b connected in series, phase terminal U, V, W being situated between them. The D.C. current is picked up at terminals B+ and B-. The circuit illustrated in Figure 1 is, as a rule, configured using individual discrete components 8a, 8b.

Converter modules in which the converter valves (diodes) and the contacts are situated on top of one another in a stack are known from DE 100 09 171 A1. The converter valves are implemented here in the form of un-encapsulated semiconductor chips. In manufacturing the known converter modules, pre-fixing elements, which are, for example, lined with synthetic resin, are necessary for positioning the contacts and the housing components. This configuration of the converter modules is relatively expensive and complicated. In addition, a triple-phase converter module generates a relatively large amount of heat loss in a small space, which may not be dissipated sufficiently.

Therefore, it is the object of the present invention to provide a converter module which has a much simpler design and which generates less heat loss.

The object of the present invention is achieved through the features cited in Claim 1 and Claim 8. Further embodiments of the present invention are the object of subclaims.

The basic idea of the present invention is to manufacture a single-phase converter module having multiple terminals and at least two semiconductor chips which are situated on top of one another in a stack, at least one of the terminals being made up of a contact plate including a bar-shaped terminal lug attached to it, the terminal lug being positioned asymmetrically on the contact plate (i.e., its longitudinal axis is situated offset to a parallel axis running through the contact plate's center of gravity) and an auxiliary element being provided at the end of the terminal lug which prevents the terminal from tilting about the terminal lug's longitudinal axis. This makes it possible to position the terminal's contact plate on a semiconductor chip without becoming canted. The auxiliary element may be detached after the stack system is assembled.

According to a preferred embodiment of the present invention, the auxiliary element has an aperture with which the appropriate terminal may be positioned in a joining device. A joining device according to the present invention has, for example, multiple guide pins and locating pins at which the terminals are aligned and held to make the stack system's assembly easier. For aligning the terminals, a guide pin and a locating pin preferably engage in the aperture provided in the auxiliary element.

According to a preferred embodiment of the present invention, the phase terminal is configured identically to the positive or negative terminal, i.e., the positive or negative terminal and the phase terminal are identical parts. In this way, the converter module may be substantially simplified and its price reduced.

The auxiliary elements provided at the terminals are preferably detached after the converter module is assembled.

The bar-shaped terminal lugs are preferably situated offset with respect to a face created by the contact plate. If the offset between the terminal lugs and the contact plates amounts to approximately one half of the height of a stack made up of one contact plate, one semiconductor chip, and two electrical connecting layers on both sides of the semiconductor chip, the terminal lugs may then be brought out from the converter module on the same level,

provided identical terminals are used for the positive terminal or negative terminal and the phase terminal. This achieves advantages with regard to the manufacturing process if the converter module is packaged in a standard plastic housing.

The converter module is preferably packaged in a standard plastic housing which is manufactured in an injection molding process. This type of packaging is particularly cost-effective.

The present invention is explained in greater detail below in an example based on the enclosed drawing, in which:

Figure 1 shows a rectifier bridge circuit including Zener diodes known from the related art;

Figure 2 shows a system of rectifier diodes in a diode stack known from the related art;

Figure 3 shows a preferred embodiment of a single-phase converter module according to the present invention having a stack-like configuration;

Figure 4 shows a ready packaged single-phase converter module; and

Figure 5 shows a line of multiple packaged converter modules.

Regarding the explanation of Figure 1, reference is made to the introductory part of the specification.

Figure 2 shows a detail of a single-phase converter module 1 in which the converter valves (Zener diodes in the present example) are situated on top of one another in a stack in the form of semiconductor chips 9. The converter module includes a positive terminal 2 (B+), a negative terminal 4 (B-), and both semiconductor chips 9 having a phase terminal 3 situated between them. As is also recognizable in Figure 2, semiconductor chips 9 have no housing.

In this case, negative terminal 4 is used simultaneously as an electric terminal, as a thermal capacitor for the back-up of peak power, as well as as a cooling terminal for dissipating the heat loss generated by the circuit.

In contrast to the triple-phase converter module known from DE 100 09 171 A1, a multi-phase converter according to the present invention is made up of multiple individual single-phase converter modules. This has the advantage that the heat loss of a multi-phase converter circuit is not concentrated in such a small space and may be better distributed.

Figure 3 shows a preferred embodiment of a single-phase converter module 1 in an exploded view. Converter module 1 includes a negative terminal 4 in the form of a metallic base (B-) which is used for mechanical stabilization and for mounting converter module 1 on a heat sink. For this purpose, negative terminal 4 includes an aperture 10 for mounting module 1 on the heat sink, by screwing on, riveting, etc.

Converter module 1 is preferably assembled in a joining device in which the individual elements of module 1 may be located and accurately positioned. The joining device may, for example, simultaneously be used as a soldering form for soldering the component/contact stack. First lower diode 9 (negative chip), then phase terminal 3, then upper diode 9 (positive chip), and finally positive terminal 2 (B+) are stacked onto base 4 during assembly of converter module 1.

The electrical connection of elements 2 through 4, 9 is established via soldering foils 8 which are situated on both sides of a semiconductor chip 9. Other standard connecting techniques such as, for example, application of conductive adhesive, soldering paste, etc. may optionally also be used.

Positive terminal 2 and phase terminal 3 are made up of a contact plate 5 having a bar-shaped terminal lug 6 and an auxiliary element 7. Bar-shaped terminal lug 6 is positioned asymmetrically on contact plate 5 (i.e., the longitudinal axis of bar-shaped terminal lug 6 is situated offset to a parallel axis running through the contact plate 5's center of gravity). Auxiliary element 7, provided at the other end of bar-shaped terminal lug 6, is designed in such a way that terminal 2, 3 does not tilt about the longitudinal axis of the bar-shaped terminal lug when the contact, for example, is supported at one point along bar-shaped

terminal lug 6. This has the advantage that contact plates 5 of terminals 2, 3 may be applied planarly on semiconductor chips 9, without terminals 2, 3 subsequently becoming canted.

Furthermore, terminals 2, 3 have a positioning aperture 11 which is preferably situated in auxiliary element 7 to be able to accurately align terminals 2, 3 at a stop of the joining device. A positioning pin, for example, of the joining device engages in shown positioning apertures 11 during assembly of the converter module.

After assembly of converter module 1, auxiliary elements 7 may be detached, if needed.

As is also recognizable in Figure 3, terminals 2 and 3 have an identical design, positive terminal 2 and phase terminal 3 being situated rotated by 180° with respect to the longitudinal axis of terminal lugs 6. In this way, converter module 1 may be manufactured in a particularly simple and cost-effective manner.

Furthermore, the bar-shaped terminal lugs of positive terminal 2 and phase terminal 3 are situated offset to the plane created by a contact plate 5. With respect to contact plate 5, bar-shaped terminal lugs 6 are offset parallel to one another, preferably by one half of the height of a stack made up of contact plate 5 of positive terminal 2, one semiconductor chip 9, and two soldering layers 8. This design makes it possible to bring out terminal lugs 6 of positive terminal 2 and of phase terminal 3 from module 1 on the same level. In addition, it is possible to use identical parts for positive terminal 2 and phase terminal 3.

Subsequent to its assembly and soldering, single-phase converter module 1 is packaged in a standard plastic housing 12.

Figure 4 shows packaged converter module 1 in a design similar to a transistor. Housing 12 shown is manufactured in a standard mold process (injection molding process). As is recognizable, converter module 1 is only packaged in the area of the chip/contact stack. Terminals 2, 3 and a mounting section of negative terminal 4 including mounting aperture 10, however, protrude from housing 12. Auxiliary elements 7 have already been detached in the illustrated state of converter module 1.

Figure 5 shows multiple packaged converter modules 1 according to Figure 4 which are connected to one another via a separable connection, in particular separable by hand (by twisting for example). For this purpose, the connection between the single-phase modules may be weakened, for example (via perforation). The desired number of single-phase converter modules 1 may thus simply be detached during the final assembly of a converter.

In the illustrated embodiment of the present invention, housings 12 of converter modules 1 are connected to one another via plastic bars 13 which are also manufactured in an injection molding process, preferably in one working step together with housings 12. Converter modules 1 may, for example, optionally also be positioned on a shared carrier foil and packaged.

Individual converter modules 1 of a module line are preferably such modules that have been either subjected to a complete electrical check prior to packaging and appropriately sorted, or manufactured directly in sequence, thus having similar electrical properties. This ensures that individual converter modules 1 of a line have only minor electrical deviations from one another.

List of Reference Numbers

1	single-phase converter module
2	positive terminal
3	phase terminal
4	negative terminal
5	contact plate
6	bar-shaped terminal lug
7	auxiliary element
8	soldering foil
9	semiconductor chip
10	mounting aperture
11	positioning aperture
12	housing
13	connecting bars
U, V, W	phases